

UNITED STATES DEPARTMENT OF AGRICULTURE

MISCELLANEOUS PUBLICATION No. 74

WASHINGTON, D. C.

MAY, 1930

AN ANNOTATED LIST OF THE IMPORTANT NORTH AMERICAN FOREST INSECTS

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GOVERNMENT PROJECTS RELATING TO FOREST INSECTS

The investigations by the United States Government of the insects affecting forest trees, forest products, and shade trees are centered in the division of forest insects of the Bureau of Entomology. The investigations carried on by the division are grouped for administrative convenience into projects, the most important of which are briefly described in the following paragraphs.

TREE-KILLING BARK BEETLES

Several species of tree-killing bark beetles of the genus *Dendroctonus* destroy annually over 6,000,000,000 feet of timber valued at from \$15,000,000 to \$20,000,000. Biological investigations of these beetles and the associated cooperation with Federal and private agencies in their control constitute one of the major activities of the division. The biological studies relate not only to the seasonal history and habits of the species, but also to the environmental factors governing the behavior of the insects in all stages of development, such as the part played by predators, parasites, and other associated insects; the effects of climate, forest type, and site; the characteristics of the trees selected for attack; and the reaction of the tree itself during and after attack. All these factors, to which

much attention is given, have an important bearing on brood development, and their study is throwing considerable light on the causes underlying the rise and fall of bark-beetle epidemics. Results have already been obtained which will have an application in timber-sale regulations, logging operations, and slash disposal. In certain cases, it has been possible, as a result of these researches, to predict the decline of epidemics and thus to save considerable money that might otherwise have been expended needlessly in direct control. These studies are centered on the national forests in California, Oregon, Montana, Arizona, Colorado, and North Carolina.

As the stumpage value of timber increases in the Western States, the protection of the great stands of mature timber from these bark-beetle losses constitutes an ever-growing problem. A considerable part of the funds appropriated is utilized in rendering service to agencies cooperating in protection from this class of insects. This service consists largely in the direction and administration of the technical features of control projects against tree-killing bark beetles as well as in the analysis of the results. In this work close cooperation is maintained with the Forest Service, the National Park Service, the Office of Indian Affairs, and private owners. At the request of these organizations or individuals surveys are made of beetle-infested areas and recommendations given as to the advisability of control measures and as to the methods to be employed. Occasionally these projects cover enormous areas and involve very complex administrative details.

Field laboratories for the regional administration of these investigations are maintained at Coeur d'Alene, Idaho, and at Palo Alto, Calif. From four to six additional temporary bases are in use during the field season.

INSECTS INJURIOUS TO FOREST PRODUCTS

From a monetary standpoint, because of the higher values involved, insects destructive to forest products take an even greater annual toll than do the bark beetles. There are a great number of insects destructive to all forms of wood products from the green felled tree to the finished seasoned article. Much time and labor have been devoted to the development of methods for preventing damage to material of this character. In many cases all that is necessary for adequate protection is to make simple alterations in the methods of handling the material in the woods, or at the mill or warehouse. Suggested modifications of building codes to insure insect-proof construction are being widely adopted (87). Again, repellent sprays or dips are effectively employed, or the wood is impregnated with chemicals that ward off insect attack. Two experimental grounds are maintained—one at East Falls Church, Va., and the other in the Canal Zone, Panama—where chemicals and wood preservatives are tested for efficiency against wood-boring insects. The Forest Products Laboratory of the Forest Service, at Madison, Wis., treats wood samples with preservatives to be tested at these experimental grounds. Cooperation is maintained, also, with many organizations interested in wood preservation.

INSECTS AFFECTING FOREST MANAGEMENT

Cooperation with the Forest Service experiment stations forms another important line of activities. At present entomologists are stationed at, or are in close touch with, five of these experiment stations, namely, the Lake States Forest Experiment Station, St. Paul, Minn., the Northeastern Forest Experiment Station, Amherst, Mass., the Appalachian Forest Experiment Station, Asheville, N. C., the California Forest Experiment Station, Berkeley, Calif., and the North Pacific Forest Experiment Station at Portland, Oreg. It is planned for the future to have entomologists assigned to each station.

The investigations carried on under this form of cooperation have to do with the insect problems involved in the management of the more important forest types of the regions. Through studies of the major forest insect pests a better understanding of the conditions favoring or retarding serious insect damage is gained, and this knowledge is made available to foresters so that it can be applied in developing sound practices in timber culture. Some species of trees and some types of forests are little affected by insects, but in others insects may be the limiting factor in successful timber production. As better cultural practices for growing timber are attempted, the complex relations existing in the forests must be more fully understood to avoid fatal mistakes. Insects constitute one of the most important of the biotic factors. Although greatest recognition is given to their rôle as destroyers of green standing timber, other important activities that bring about changes in the composition of the forest can not be disregarded. Insects often increase the percentage of undesirable species of trees, inhibit the reproduction of certain desirable species, affect the rate of growth, and thus lengthen the rotation period and augment the ill effects of fire. Investigations dealing with these varied problems are under way.

Some other problems of a more specific character are under investigation, such as the entomological aspects of slash disposal (72), the interrelation of insects and forest fires (78, 79), turpentine practices and insect damage, insects affecting nursery practices, and insect injury to the seed of forest trees.

INSECTS INJURIOUS TO SHADE TREES AND ORNAMENTAL SHRUBS

Little in the way of investigation of insects affecting shade and ornamental trees and hardy shrubs is done at the present time, and most of the effort in this work is expended in service. There is a great and increasing demand from municipal authorities, estate owners and managers, small property owners, tree surgeons, and nurserymen for advice on methods of handling their entomological problems. The division of forest insects attempts to meet this demand by correspondence, publications, and occasional surveys and studies. Whenever possible, observations are made on important species and, where practical, experiments in methods of control and improvements in such methods are conducted.

THE MOST IMPORTANT FOREST INSECTS

This list includes those species of forest insects which are of the greatest economic importance at the present time. In the discussion of each species the common and technical names are given. There is added some information on the occurrence of the insect, the character of damage or notable epidemics, and the most important or available references to it in literature.

For the convenience of those not acquainted with the systematic classification of insects, the species listed have been arranged in groups according to the type of damage, such as bark beetles, leaf feeders, etc., and these groups are further subdivided as necessary.

TREE-KILLING BARK BEETLES

THE SOUTHERN PINE BEETLE

Dendroctonus frontalis Zimm.

In the southeastern part of the United States the southern pine beetle stands out as the most important tree-killing bark beetle. This species becomes exceedingly abundant at irregular intervals; and for several years, during one of these outbreaks, thousands of pines may be attacked and killed. In 1910 and 1911 timber valued at over \$2,000,000 was destroyed (1, 40, 42)¹.

THE EASTERN SPRUCE BEETLE

Dendroctonus piceaperda Hopk.

In past years, before the virgin spruce forests of the Northeast were cut, this bark beetle was responsible for serious depredations. Of late years little timber has been killed by this beetle in the United States, though serious losses are reported from Canada (42).

THE TURPENTINE BEETLES

Dendroctonus valens Lec.

Dendroctonus terebrans Oliv.

The red turpentine beetle (*Dendroctonus valens*) and the black turpentine beetle (*D. terebrans*) are widely distributed in North America. They attack the bases and roots of practically all species of pine and spruce, causing the exudation of large masses of pitch. They rarely kill trees and are of importance more as a result of the attention they attract than because of the damage inflicted (1, 30, 42, 46).

THE MOUNTAIN PINE BEETLE

Dendroctonus monticolae Hopk.

The mountain pine beetle has a very wide range, extending from the Sierras of central California through the northern Rockies into Canada. It attacks lodgepole, sugar, western white, and yellow pines. Nearly every year severe outbreaks are in progress in some part of this area. One notable infestation has been progressing since 1909 and now bids fair to destroy practically all the lodgepole pine on the Bitter Root and Beaverhead National Forests (42, 46).

¹ Reference is made by italic numbers in parentheses to Literature Cited, p. 23.

THE BLACK HILLS BEETLE

Dendroctonus ponderosae Hopk.

The Black Hills beetle is the most destructive enemy of yellow pine in the Rocky Mountain region. It has a marked tendency to increase suddenly to extraordinary numbers and, after destroying great quantities of timber, to subside quickly. Notable epidemics occurred in the Black Hills from 1898 to 1905 and in the Kaibab National Forest from 1920 to 1925 (42).

THE DOUGLAS FIR BEETLE

Dendroctonus pseudotsugae Hopk.

The Douglas fir beetle is most destructive in the northern Rockies and Canada. It seldom kills Douglas fir west of the Cascade Range. Outbreaks are local and sporadic, frequently associated with windthrows, defoliations, or logging operations (42).

THE WESTERN PINE BEETLE

Dendroctonus brevicomis Lec.

The western pine beetle occurs over practically the same territory as the mountain pine beetle and extends to the southern limit of the yellow pine type in California. This species rarely causes spectacular outbreaks but takes an annual toll of from 0.1 per cent to occasionally 5 per cent of the stand. It is of economic importance only in the western yellow pine forests (42, 46).

THE SOUTHWESTERN PINE BEETLE

Dendroctonus barberi Hopk.

In habits this species resembles its near kin, the western pine beetle, though it is not so destructive. Occasional outbreaks in southern Colorado, Arizona, and New Mexico take a considerable toll of timber but are short-lived. The activities of the beetle increase in years of drought (42).

THE JEFFREY PINE BEETLE

Dendroctonus jeffreyi Hopk.

The Jeffrey pine beetle restricts its activities entirely to the tree for which it is named. It is most injurious in the forests east of the Sierras, where it normally takes a small annual toll. Following a severe windstorm in the Inyo National Forest, Calif., some 6,000,000 feet of timber were killed by this species in 1924 and 1925 (42, 46).

THE ENGRAVER BEETLES

Ips spp.

The engraver beetles of the genus *Ips* are represented by numerous species. They are usually associated with dying or recently felled softwoods. Occasionally they contribute to the death of timber weakened from other causes and may even kill outright healthy timber when they are present in great numbers. Sporadic out-

breaks, in which large groups of young trees and occasionally mature trees are killed, often follow drought, windfalls, and slashings. Epidemics will not continue in healthy timber because the broods fail to develop, and such outbreaks as occur are short-lived. In the southern part of the United States the three most important species of *Ips* are *grandicollis* Eichh., *calligraphus* Germ., and *avulsus* Eichh. In the Western States *confusus* Lec., *emarginatus* Lec., *integer* Eichh., *oregoni* Eichh., and *radiatae* Hopk. are the most destructive species. *I. oregoni* very commonly kills the tops of mature western yellow pines, rendering the trees susceptible to the attack of *Dendroctonus* beetles (1, 46, 58, 63, 66).

MONTEREY CYPRESS BARK BEETLE

Phloeosinus cristatus Lec.

Several species of *Phloeosinus*, a genus of bark beetles, apparently are capable of killing trees belonging to those genera allied to *Cupressus*. This species seems to be particularly aggressive in Monterey cypress planted in the vicinity of San Francisco. It is usually associated, however, with scale insects and fungi, and its specific role has not been accurately determined.

THE HICKORY BARK BEETLE

Scolytus quadrispinosus Say

The hickory bark beetle is an important enemy of hickory in the Eastern States. Every few years local outbreaks of the hickory bark beetle destroy considerable timber in the natural range of the tree from Massachusetts southward to Georgia and westward into the Mississippi Valley. Recent studies indicate that these outbreaks are correlated with droughts or conditions unfavorably affecting the trees (2, 43).

THE FIR BARK BEETLE

Scolytus ventralis Lec.

This species, widely distributed throughout the Western States, attacks standing dead, dying, or living firs, frequently killing them but more often destroying only the tops of the trees or patches of bark on the trunk, which results in defects. In California, following the drought of 1924, very extensive losses were reported (40, 46).

INSECTS BORING IN LIVING TREES

THE SMALL METALLIC WOOD AND BARK BORERS

Agrilus anxius Gory

Agrilus bilineatus Web.

The bronze birch borer (*Agrilus anxius* Gory) is very destructive to several species of birch (*Betula*) in the Northeast. Its control is becoming an important problem in the management of hardwood stands. The 2-lined chestnut borer (*A. bilineatus* Web.) is of secondary importance throughout the eastern part of the United States. It occasions the death of oaks weakened by other causes, though in Minnesota it is reported to be more of a primary pest (8, 14, 57, 59).

THE TURPENTINE BORER

Buprestis apricans Hbst.

The turpentine borer attacks the exposed wood resulting from fire scars, blazes, and turpented faces of several species of southern pines, making the trees susceptible to windthrow, and the butt log unfit for lumber. In recent years, with the wider adoption of conservative turpentine practices and forest management, injury by this insect is receiving greater recognition (8, 19).

THE LOCUST BORER

Cyllene robiniae Forst.

The locust borer frequently prevents the growth of a valuable tree, the black locust, in some regions. It occurs throughout the Eastern States and has been introduced with the host into Colorado and adjacent States (17, 29, 41).

THE OAK TWIG PRUNER

Elaphidion villosum Fab.

The oak twig pruner, occurring throughout the eastern half of the United States, locally causes serious damage to various hardwoods by cutting off the branches. The pruning in this case is done by the larvae (48).

THE SUGAR MAPLE BORER

Glycobius speciosus Say

The sugar-maple borer is an especially injurious pest of the sugar maple tree in the Northeastern States. This borer attacks trees apparently in full vigor, especially those growing in the open, and kills limbs and sometimes the entire tree. This insect is probably the most serious enemy of the sugar maple tree (25).

THE LIVING HICKORY BORER

Goes pulcher Hald.

THE LIVING BEECH BORER

Goes pulverulenta Hald.

THE WHITE OAK BORER

Goes tigrina DeGeer

THE OAK SAPLING BORER

Goes tessellata Hald.

The four species of roundheaded borers listed above attack the trunks of a variety of hardwoods, including oak, hickory, beech, elm, sycamore, blue beech, and ironwood, throughout the eastern part of the United States. The larvae bore deeply into the wood, causing large, unsightly defects and culls in the lumber. In younger trees these defects frequently cause breakage under the strain of wind or ice storms (18).

THE PINE AND HEMLOCK FLAT-HEAD BORERS

Melanophila spp.

Two species of the genus *Melanophila*, the eastern hemlock bark borer (*M. fulvoguttata* Ham.) and the western flat-headed borer (*M. gentilis* Lec.), are of considerable economic importance. The eastern form kills hemlock weakened by defoliation and other causes. The western species is frequently an important pest during epidemics of the western-pine bark beetle in western yellow pine and to trees affected by drought (8, 46).

THE TWIG TUNNELERS

Oberea spp.

Several species of *Oberea* bore down through the pith in the twigs of several species of trees and shrubs, causing the death of the infested portion. The work can always be distinguished from that of other twig girdlers by the linear series of small holes cut through the bark. *O. myops* Hald. in rhododendron and azalea, *O. schaumii* Lec. in poplar, and *O. tripunctata* Fab. and *O. bimaculata* Oliv. in plum, apple, peach, and dogwood are the most important (18).

THE LONG-HORNED GIRDLERS

Oncideres cingulata Say*Oncideres putator* Thom.

The hickory twig girdler (*Oncideres cingulata*) and the huisache girdler (*O. putator*) cause considerable damage to a great variety of hardwood trees in the Eastern and Gulf States by cutting off the branches. The girdling is done by the adult beetle (18, 37).

THE COTTONWOOD BORER

Plectrodera scalator Fab.

In the central part of the United States the cottonwood borer causes serious injury to the base and roots of several species of cottonwood and willow. It is sometimes abundant enough in certain localities to kill these trees (52).

THE PRIONID ROOT BORERS

Prionus spp.

Several species of these large roundheaded borers—*Prionus latcollis* Drury and *P. imbricornis* L. in the East, and *P. californicus* Motschulsky in the Western States—bore in the roots of living hardwoods, thus lowering the vitality of the trees. The attack is frequently followed by root rots such as *Armellaria* and attacks of secondary bark borers which ultimately kill the trees (16).

THE RED OAK BORER

Romaleum rufulum Hald.

The red oak borer is of considerable economic importance throughout its range in the central and eastern part of the United States and Canada. The habits of this species somewhat resemble those of

Prionoxystus and Goes. The borers attack living oak trees, mining deeply into the sapwood and heartwood (18).

THE ELM BORER

Saperda tridentata Oliv.

THE LINDEN BORER

Saperda vestita Say

THE POPLAR BORER

Saperda calcarata Say

The larvae of the poplar borer riddle the heartwood of several species of poplar, opening it to decay and making the trees subject to windfall. It is widely distributed throughout the range of the host plants. Several other species of this genus, among which *Saperda tridentata* in elm and *S. vestita* in linden are important, are injurious to living trees (18, 27, 38).

THE WESTERN FIR BORER

Tetropium abietis Fall

In the Pacific coast region the western fir borer occasionally kills large numbers of true firs by mining beneath the bark. Trees weakened by defoliation or fire are particularly susceptible to attack (18).

THE WESTERN LARCH BARK BORER

Tetropium velutinum Lec.

The western larch bark borer is occasionally a pest of considerable importance in stands of western larch and hemlock in the Rocky Mountain and Pacific coast regions of the United States. The larvae mine in the inner bark (18, 68).

THE CEDAR POLE BORER

Trachykele blondeli Mars.

The larvae of the western cedar pole borer riddle the heart and sapwood of living western red cedar, causing serious defects and the consequent rejection of the damaged material for lumber, shingles, and poles. This borer occurs in Oregon, Washington, and California (9).

THE PITCH MOTHS

Dioryctria abietella D. and S.

Dioryctria xanthaenobarea Dyar

Dioryctria ponderosae Dyar

Dioryctria amatella Hulst

The inner bark of the trunks, the new growth of the leaders, and the cones, of pine, Douglas fir, spruce, and fir are often seriously injured by the caterpillars of the pitch moths. Death of parts or even the entire tree and the loss of seed of the infested cones frequently follow the injury. These insects are important, but little work has been done on them.

THE ZIMMERMAN PINE MOTH

Pinipestis zimmermani Grote

The Zimmerman pine moth is a serious insect pest of pine, attacking western yellow pine, white pines, Scotch pine, and Austrian pine. The caterpillar bores into the bark of the trunk, usually avoiding the base and top, and causes the malformation known as spike top or sometimes kills the entire tree. The injury it produces also brings about a considerable depreciation in the value of the timber. The species is especially abundant in the northern and western part of the United States (6).

THE CARPENTER WORM

Prionoxystus robiniae Peck

The larvae of this large moth bore in a great variety of eastern hardwoods, especially oak and locust, causing large wormholes and resulting defects in the lumber (44, 48).

THE DOUGLAS FIR PITCH MOTH

Synanthedon novaroensis Hy. Edw.

The Douglas fir pitch moth is an important enemy of Douglas fir over the northern Rocky Mountain and Pacific coast regions. The insect causes pitch seams, gum check, and other defects which seriously depreciate the value of the timber. Its attack appears to be restricted to that portion of the trunk which later clears itself of branches (5).

THE SEQUOIA PITCH MOTH

Vespamima sequoiae Hy. Edw.

The Sequoia pitch moth attacks almost all conifers of the Northwest. It is particularly abundant and destructive to lodgepole pine in certain regions of Montana. The insect infests the extreme base of the trees, causing a heavy pitch flow over the base of the trunk and surrounding ground. The trees attacked are frequently killed and jeopardize other trees in the neighborhood through increased fire hazard (4).

THE LEOPARD MOTH

Zeuzera pyrina Fab.

The leopard moth kills the limbs of hardwood trees and is locally serious in the New England and the Northeastern States. The species was introduced from Europe and is spreading slowly to the South and West (45).

THE CAMBIUM MINERS

Agromyza aceris Greene*Agromyza amelanchieris* Greene

Birch, cherry, maple, oak, poplar, and many other less commonly used hardwood trees have small, yellowish-brown spots or streaks called "pith flecks" made by the larvae of several species of flies, the names of two species being given above. In the Eastern States this injury sometimes lowers the grade of the product for certain uses (34).

THE HEMLOCK BARK MAGGOT

Cheilisia alaskensis Hunter

The hemlock bark maggot in the northern Rocky Mountain and Pacific coast regions causes defects in western hemlock known as "black check." The injury is caused by the larvae working in the growing tissue of the tree. Similar defects in fir, spruce, and pine are caused by related species (7).

INSECTS AFFECTING FOREST PRODUCTS

AMBROSIA BEETLES OR PINHOLE BORERS

A number of species of beetles included in the genera *Corthylus*, *Gnathotrichus*, *Pterocyclon*, *Xyleborus*, and *Platypus* are important because of the injury they do to fire-scarred trees, green logs, and green lumber. These insects, while working in the wood, not only make holes but also introduce wood-staining fungi. In some localities a considerable quantity of wood otherwise sound and useful is discarded because by the work of these beetles it is rendered unfit for certain special uses (39, 40, 62).

THE COLUMBIAN TIMBER BEETLE

Corthylus columbianus Hopk.

The Columbian timber beetle attacks living white oak, chestnut, and yellow poplar, entering directly through sound bark. In some localities from 15 to 25 per cent of the white oak lumber may be affected, and where tight barrel staves are being manufactured whole trees are discarded because of injury by this insect. The wood may still be used for such purposes as base for veneer and for the invisible parts of various structures, as its strength is little impaired (39, 40, 62).

THE OAK TIMBER WORM

Eupsalis minuta Drury

The oak timber worm, entering through wounds, attacks the wood of living trees and also frequently causes much damage to green logs and produces defects in the lumber. It occurs throughout the eastern part of the United States (39, 40, 62).

THE CHESTNUT TIMBER WORM

(*Lymexylon*) *Melittomma sericeum* Harris

The chestnut timber worm attacks the wood of living chestnut. Entering through a wound, it bores deeply into the center of the tree. In the recent past, when chestnut was a more abundant forest tree, this insect presented a serious problem, as from 75 to 90 per cent of all the chestnut timber produced was defective (39, 40, 62).

THE SAPWOOD TIMBER WORM

Hylecoetus lugubris Say

The sapwood timber worm attacks dying trees and green saw logs of basswood, buckeye, chestnut, black walnut, cottonwood, yellow poplar, and birch, causing considerable damage. Often a 5 to 10 per cent loss occurs in logs on which the bark has been left (40, 62).

THE BLACK-HORNED PINE BORER

Callidium antennatum Newm.

The black-horned pine borer attacks a variety of softwoods and, together with other closely allied species, is widely distributed over the United States. Considerable damage is caused to rustic houses and other structures where these woods with the bark still on are used for support or ornamentation. The presence of bark is necessary for attack by this species (18, 68).

THE BELTED CHION

Chion cinctus Drury

The belted chion, a long-horned borer, attacks several species of partly seasoned hardwoods, causing severe damage to the sapwood of oak and hickory, often making holes from one-half to three-fourths of an inch wide and 2 feet long and rendering it unfit for construction purposes. This insect will attack wood even after the bark has been removed from the log. Small stock used in the manufacture of rustic furniture or in making small products, such as mallets and mauls, is subject to severe damage by this insect (18, 62, 68).

THE PAINTED HICKORY BORER

Cyllene caryae Gahan

The painted hickory borer causes serious injury to green saw logs. The larvae make large oval holes in the sapwood. This part of the log, which should furnish the best grades of material, is often ruined by the resulting defects in the lumber. Besides hickory this borer attacks walnut, honeylocust, mulberry, and osage orange (18, 22).

THE WESTERN CEDAR BARK BORER

(Hylotrupes) Hemicallidium amethystinum Lec.

The western cedar bark borer is of considerable economic importance in the Pacific coast region of the United States. It injures wood of recently felled giant arborvitae and incense cedar (18, 68).

THE OLD HOUSE BORER

Hylotrupes bajulus L.

The old-house borer attacks a variety of dry, seasoned, softwood products. This species, introduced from Europe, is of considerable economic importance and is becoming more abundant and serious each year. It confines its activities to such materials as joists, studding, and rafters (18, 62).

THE CEDAR-TREE BORER

Hylotrupes ligneus Fab.

The cedar-tree borer attacks a variety of softwoods (firs, spruces, hemlocks, cedars, arborvitae, etc.), damaging the wood for commercial purposes and causing shedding of the bark of material used in rustic work. The larvae mine first between the bark and wood and later in the sapwood, occasionally going into the heartwood (18, 68).

THE PINE SAWYERS

Monochamus spp.

Several species of pine sawyers are of economic importance, namely, *Monochamus titillator* Fab. in the Southeast, *M. scutellatus* Say and *M. confusor* Kirby in the Northeast, and *M. maculosus* Hald. in the West. They attack dying and recently felled pine, spruce, and fir, their work resulting in a high percentage of culled lumber. Following windfalls and burns these species are especially destructive, causing rapid deterioration of the timber before it can be salvaged. *M. marmorator* Kirby attacks and kills living fir (*Abies balsamea*) in the Northeastern States and Canada (18, 67).

THE BANDED ASH BORER

Neoclytus capraea Say

The banded ash borer is of considerable economic importance in the eastern part of the United States, causing extensive damage to the sapwood and outer heartwood of recently felled and partly seasoned ash logs. In some large operations the grub of this beetle has been known to have completely destroyed the entire cut of one season (18, 62, 68).

THE GRAY ASH BORER

Neoclytus conjunctus LeConte

This beetle has habits similar to those of the banded ash borer. The grub mines the sapwood and heartwood of ash and oak. It is a common species in the Rocky Mountain region and in the Pacific Coast States (18).

THE RED-HEADED ASH BORER

Neoclytus erythrocephalus Fab.

The red-headed ash borer attacks recently felled hardwoods of a number of varieties, often causing from 20 to 90 per cent loss in the lowering of the grade of the lumber. Ash and hickory particularly are selected for attack. Green logs, felled during the summer in the Gulf coast and Mississippi Delta areas and left in the woods for several weeks before being removed, often suffer a total loss as the result of the activities of this insect (18, 68).

THE POLE BORER

Parandra brunnea Fab.

The pole borer is a fairly large wood borer which causes considerable damage to the bases of telephone poles and to shade trees throughout the eastern part of the United States. Telephone poles are sometimes completely severed, and the entire heart is eaten out of shade trees causing large limbs to fall or the entire tree to break over.

THE TANBARK BORER

Phymatodes variabilis Fab.

The tanbark borer is of economic importance in the tanbark industries. The grub of this beetle mines chiefly in the bark of oak (18, 39, 68).

THE FLAT OAK BORER

Smodicum cucujiforme Say

The flat oak borer is a typical heartwood feeder that attacks seasoned oak and hickory products. Its work is also often found in old fire scars on oak trees (18).

THE POWDER-POST BEETLES

Lyctus planicollis Lec. and other species of *Lyctus*

Several species of the so-called lyctus powder-post beetles are extremely destructive to seasoned hardwoods, particularly oak, hickory, ash, persimmon, etc. The annual loss to such stored products as billets, lumber, handles, and spokes runs into millions of dollars (61).

THE LEAD-CABLE BORER

Scobicia declivis Lec.

The lead-cable borer is a serious pest of oak stave wood on the west coast and has an interesting and expensive habit of boring into suspended lead-sheathed telephone cables (10).

THE RED-SHOULDERED POWDER-POST BEETLE

Xylobiops basilaris Say

The red-shouldered powder-post beetle is of considerable economic importance, causing large losses to partly seasoned wood products used in the manufacture of shuttle blocks, mallets, mauls, etc., as well as to small poles and saplings used for rustic furniture. Hickory and persimmon blocks and poles are destroyed by both adults and grubs and literally reduced to powder in a few months' time (40, 53).

OTHER BOSTRICHID POWDER-POST BEETLES

Apatides fortis Lec.*Dendrobiella aspera* Lec.

Other powder-post beetles occur in the Southwest and attack mesquite, reducing the wood to powder within a short time. The large form, *Apatides fortis*, prefers wood which has dried for several months, but the smaller form, *Dendrobiella aspera*, shows a decided preference for freshly cut wood. Fence posts, poles, and cordwood are severely damaged (20).

THE CARPENTER ANT

Camponotus herculeanus pennsylvanicus DeG.

The carpenter ant is widespread and abundant in the United States. It attacks living trees through wounds, dead trees, logs, and forest products, frequently entering the wooden parts of buildings.

TERMITES (NONSUBTERRANEAN)

Kalotermes spp.

In certain sections of the United States, namely, the South Atlantic, Gulf, Southwestern, and Pacific Coast States, nonsubter-

anean or dry-wood termites (*Kaloterms* spp.) seriously damage the woodwork of buildings and furniture, and telegraph, telephone, power, and electric-light poles. These termites are able to live in dry wood and do not need to maintain contact with the ground as they do not require much moisture (60).

TERMITES (SUBTERRANEAN)

Reticulitermes spp.

The most injurious termites throughout the entire United States are ground-nesting or subterranean forms (*Reticulitermes* spp.). The regions where damage is most serious are portions of the country with warm or temperate climates, including the Eastern States, the central West, and the Pacific coast, as well as all areas south of these regions. These termites are chiefly injurious to wood either in contact with the ground or insufficiently protected, insulated, or removed from the ground. The annual damage caused by these termites in the United States is many millions of dollars, these losses being due not only to the value of the wood destroyed but also to the cost of labor of removal, reconstruction, or replacement (60, 87).

INSECTS AFFECTING SEEDS, FOREST REPRODUCTION, AND NURSERY PLANTS

THE SPRUCE TWIG GALL LICE

(*Chermes* or *Gillettea*) *Adelges cooleyi* Gill.

(*Chermes*) *Adelges abietis* L.

These insects and other related species are important forest, nursery, and ornamental-tree pests, producing characteristic twig-deforming growths which frequently kill the parts attacked. They occur throughout the natural range of the spruces and firs.

THE NUT WEEVILS

Curculio spp.

Weevils of this group are important destroyers of the seeds of certain hardwood trees. Hickory nuts, acorns, chestnuts, and hazelnuts are heavily infested by these snout beetles which make the seed unviable with a resultant loss in reproduction. Infestation in seeds collected for nursery planting occasionally exceeds 20 per cent (3, 25, 47).

THE CONE BEETLES

Conophthorus spp.

The cone beetles bore into the base of the developing cones of many species of pine. Drying and falling, or prolonged retention of the cones, may follow the attack. In some years, in restricted localities, the entire seed crop is destroyed. The more important species are *Conophthorus ponderosae* Hopk., the yellow pine cone beetle; *C. lambertianae* Hopk., the sugar pine cone beetle; and *C. coniperda* Sz., the eastern white pine cone beetle (46, 50, 51).

ACORN GALL MAKERS

Cynipidae

A number of 4-winged gallflies destroy large quantities of oak seed by producing gall formations in the cotyledons. They lower the natural reproduction of oak and are also responsible for a heavy loss in collected seed (26).

SEED CHALCIDS

Megastigmus albifrons Walk.

Megastigmus milleri Rohwer

Megastigmus piceae Rohwer

Megastigmus pinus Parfitt

Megastigmus spermatrophus Wachtl

The seeds of many trees are attacked by certain chalcids that feed on plant tissue. These small, 4-winged flies destroy the seeds of pine, spruce, fir, juniper, and many other trees. The Douglas fir chalcid (*Megastigmus spermatrophus*) is at times particularly destructive (50).

THE PALES WEEVIL

Hylobius pales Boh.

The pales weevil destroys young pine seedlings. The larvae breed in green pine stumps and logs, and the adults girdle pine seedlings from 1 to 5 years old by feeding at the base. The inroads of this beetle frequently make several plantings necessary in order that a fully stocked stand may be secured.

The species is injurious chiefly in the New England States (56).

THE PINE BARK LOUSE

(*Chermes*) *Pineus pinicorticis* Fitch

The pine bark louse, a relative of the spruce twig gall lice, occurs on the bark and needles of white pine producing a waxy secretion which appears as a whitish gray mold. Trees heavily infested for several years show the effect in scant, poor-colored foliage and stunted new growth.

MAY BEETLES OR WHITE GRUBS

Phyllophaga spp.

The control of the larvae or white grubs of a number of species of May beetles constitutes an important problem in nurseries of both forest and ornamental stock. These insects kill large numbers of both evergreen and deciduous seedling trees and shrubs by feeding on the roots. The beetles when abundant defoliate hardwood trees (21).

THE WHITE PINE WEEVIL

Pissodes strobi Peck

The white pine weevil is the most serious pest of white pine in the Northeastern States. Successive killing of the terminal shoots

of saplings and young trees results in stunting and malformation and ultimately in low-grade timber. Over 75 per cent of the white pines in this region are weeviled, resulting in a reduction in value of from 20 to 25 per cent below that of trees of normal development (32).

THE EUROPEAN PINE-SHOOT MOTH

Rhyacionia buoliana Schiff.

This imported pine-shoot moth, first found in the United States in 1914, is known in Europe as a very serious pest. The species is confined to pine but is recorded as attacking "all species" of this genus. It has been found in this country on Scotch pine, Austrian pine, mugho pine, white pine, red pine, and longleaf pine. This moth has become established in Illinois, Ohio, West Virginia, Pennsylvania, New Jersey, New York, Massachusetts, Connecticut, Rhode Island, and Florida. At present it seems to be largely a nursery pest.

THE NANTUCKET PINE MOTH

Rhyacionia frustrana Comst.

The Nantucket pine moth is common on young pine throughout the Eastern and Southern States. Periodically it becomes of great importance locally. Some years ago it was introduced into the Forest Service plantations at Halsey, Nebr., where it has become established and is proving very injurious, especially to western yellow pine, the most desirable tree species (33, 53, 65).

THE PINE NEEDLE SCALE

Chionaspis pinifoliae Fitch

The pine needle scale is one of the few scale insects that are serious forest pests in the United States. It occasionally becomes sufficiently abundant in the forests of California and Minnesota to weaken the trees and make them susceptible to bark-beetle attack. It is also an important pest of ornamental pine and spruce (23, 44).

THE CYPRESS BARK SCALE

Ehrhornia cupressi Ehrhorn

Monterey cypress in California, especially trees in thickly planted hedgerows or windbreaks, are severely injured by this scale insect (23, 35).

THE PINE SOFT SCALES

Toumeyella spp.

Toumeyella numismaticum (P. and McD.), *T. parvicorne* Ckll., *T. pini* King, and unidentified species of this genus have been reported as injurious to pines east of the Rocky Mountains. *Pinus sylvestris*, *P. divaricata*, *P. radiata*, *P. virginiana*, and *P. mugho* are recorded as hosts from Louisiana, Michigan, Minnesota, Nebraska, North Carolina, and Pennsylvania. *T. numismaticum* promises to be an important pine nursery problem, as it has appeared in injurious numbers in forest-tree nurseries of the South and has killed many

trees in the plantations of the Nebraska National Forest at Halsey, Nebr., and in Minnesota.

DEFOLIATING INSECTS

THE LOCUST LEAF MINER

Chalepus dorsalis Thunb.

The locust leaf miner causes widespread defoliation of black locust. It is abundant practically every year over considerable areas of its range from Massachusetts through the southern Appalachians and the Ohio Valley. The feeding causes the leaves of the trees to turn brown in the late summer. No study has been made of its effect on the growth of the trees (48, 53).

THE GRAPE COLASPIS

Colaspis brunnea Fab.

Widespread defoliation of pines in the Gulf States in 1925 and 1926 was attributed to this small beetle. The species is not often so abundant. Severest injury occurred in southern Louisiana and eastern Texas. Young trees were more severely infested than older ones.

THE ORANGE-STRIPED OAK WORM

Anisota senatoria A. and S.

THE SPINY OAK WORM

Anisota stigma Hbn.

THE GREEN-STRIPED MAPLE WORM

Anisota rubicunda Fab.

Throughout the eastern hardwood belt oaks are frequently defoliated by the orange-striped oak worm, the spiny oak worm, and *Anisota virginiensis* Drury, and maples by the green-striped maple worm. The first-mentioned species is the most important and injurious (25, 44, 48).

THE BIRCH LEAF SKELETONIZER

Bucculatrix canadensisella Chambers

This insect is a frequent defoliator of birch throughout the northern part of the United States and Canada and feeds to some extent on alder and oak.

THE SPRUCE BUD WORM

Cacoccia fumiferana Clem.

The spruce bud worm is periodically one of the most destructive forest insects in the United States. A recent epidemic in the Northeastern States and Canada destroyed from 50 to 75 per cent of the spruce and fir over great areas. In the Lake States and locally throughout the Rocky Mountains notable losses have been reported. The caterpillars feed on fir, spruce, Douglas fir, pine, larch, and hemlock (64).

THE CATALPA SPHINX

Ceratomia catalpae Bdv.

Catalpas are frequently defoliated by the caterpillar of the catalpa sphinx moth. When the trees are grown in plantations this insect occasionally becomes extremely abundant and destructive. The most serious injury has occurred in the Ohio Valley (44, 48).

THE LARCH CASE-BEARER

Coleophora laricella Hbn.

The larch case-bearer, introduced from Europe, has become widely distributed in the northeastern part of the United States, the Lake States, and Canada and is causing considerable injury to larch. An extensive outbreak of this insect occurred in New England from 1923 to 1925 and in Maine thousands of acres of larch were defoliated. The trees which were stripped annually began to die in 1926.

THE PANDORA MOTH

Coloradia pandora Blake

This species causes serious defoliation of western yellow pine and lodgepole pine growing on the volcanic soils east of the Sierra Nevada and Cascade Ranges in California and Oregon. Trees are defoliated only in alternate years and, although few die as a direct result of defoliation, they are rendered more susceptible to bark-beetle attack (55).

THE YELLOW-NECKED CATERPILLAR

Datana ministra Walk.

THE WALNUT CATERPILLAR

Datana integerrima G. & R.

These two species of *Datana* are occasionally important. The yellow-necked caterpillar is a general feeder and is sometimes abundant in hardwood forests. The walnut caterpillar is a frequent defoliator of walnut trees throughout the eastern hardwood belt (25, 44, 48).

THE HEMLOCK LOOPERS

Ellopia spp.

Hemlock, spruce, and Douglas fir in the Lake States and on the Pacific coast are sometimes very severely defoliated and killed by several species of caterpillars belonging to the genus *Ellopia*. *E. fiscellaria* Gn. in the Lake States, *E. somniaria* Hulst in the northern Pacific States, and an undetermined species in California are the most important (28).

THE DOUGLAS FIR LOOPER

Galenara sp.

At higher elevations in the spruce-fir type of the southern Rocky Mountain region, particularly in New Mexico, the Douglas fir looper

has periodically destroyed the timber over considerable areas. Several recent outbreaks have occurred in the Sacramento Mountains. Douglas fir is the favored host but spruce foliage is eaten as well. *Dendroctonus engelmanni* frequently follows and destroys not only weakened trees but vigorous stands outside the area of defoliation.

THE LODGEPOLE NEEDLE TIER

Argyrotaenia pinatubana Kearf.

The lodgepole needle tier, supposed to be the same as the defoliator of eastern white pine, became very abundant in 1920 to 1925 on the headwaters of the Madison River in Yellowstone National Park and the Madison National Forest. In conjunction with a sawfly (*Neodiprion* sp.) these insects killed most of the lodgepole pine over an area of 75 square miles.

THE BROWN-TAIL MOTH

Nygmia phaeorrhoea Donovan

The brown-tail moth is an insect which has been introduced and become established in the New England States. It is locally and periodically abundant, defoliating apple, pear, plum, oak, willow, elm, maple, and other common trees and shrubs. It does not attack conifers. The hairs from the caterpillars are a source of annoyance, causing a rash and irritation of the skin (12).

THE DOUGLAS FIR TUSsock MOTH

Hemerocampa pseudotsugata McD.

This defoliator has come into prominence as an insect of economic importance within the last ten years in the northern Rocky Mountain regions, Washington, and British Columbia. Locally through this region it has killed a great deal of Douglas fir, but the outbreaks usually disappear in about three years. The female is wingless. The caterpillars shed poisonous hairs which cause a rash on susceptible skins.

OAK AND MAPLE DEFOLIATORS

Heterocampa spp.

Caterpillars belonging to the genus *Heterocampa* occasionally become exceedingly abundant in hardwood forests and severely defoliate trees over large areas. In 1918 and 1919 maple and birch were severely defoliated in New Hampshire by *Heterocampa bilineata* Pack. and *H. biundata* Walk., and elm in Essex County, N. Y., by *H. bilineata* in 1918. *H. guttivitta* Walk. defoliated maples, birch, and beech in New York, Vermont, and New Hampshire in 1910 and 1919. *H. manteo* Dbdy. defoliated forest trees, oak, beech, maple, and hickory, in 1922 over an extensive area involving Virginia and North Carolina. Many oaks were completely stripped. In most of these defoliations caterpillars of more than one genus were reported present although species of *Heterocampa* played the dominant rôle (15, 25).

THE TENT CATERPILLARS

Malacosoma disstria Hübn.

Malacosoma americana Fab.

Malacosoma californica Pack.

Malacosoma constricta Stretch

Malacosoma pluvialis Dyar

Malacosoma fragilis Stretch

The tent caterpillars are frequently important forest defoliators as well as farm and orchard pests. They have a wide range of host plants. Some species are widely distributed over the United States, whereas others are rather restricted in distribution. A recent infestation on the Carson National Forest in New Mexico spread from 10 sections in 1926 to approximately 225 sections in 1929 (23, 25, 48).

THE PINE BUTTERFLY

Neophasia menapia Felder

At irregular periods large areas of western yellow pine, western white pine, and lodgepole pine are defoliated in Idaho, Montana, and the Pacific Coast States by caterpillars of the pine butterfly. Death of the trees through loss of the needles or attack by bark beetles follows severe defoliation (24).

THE HEMLOCK BUDWORM

Peronea variana Fern.

The hemlock budworm, as recognized at present, occurs in the northeastern part of the United States and Canada as well as in the Pacific Northwest, British Columbia, and Alaska. At times it is extremely destructive over wide areas, feeding chiefly on hemlock, although the spruces and firs are also attacked. At present active outbreaks occur along the St. Lawrence River in the eastern part of Canada and on the Olympic peninsula on the Pacific Coast. Little is known of its habits.

THE GIPSY MOTH

Porthetria dispar L.

The control of the gipsy moth is a problem in the care of shade, park, and forest trees in the New England States. The nearly omnivorous feeding habits of the larvae of this insect and the methods of pupation and egg laying have rendered it a pest exceptionally difficult to control. It has killed many trees, particularly oaks, in the infested area (12).

THE CALIFORNIA OAK WORM

Phryganidia californica Pack.

Considerable areas of oaks on the Pacific coast are frequently defoliated by the caterpillars of the California oak moth. This species is at times sufficiently abundant and injurious to demand control measures (11).

THE PINE NEEDLE MINER AND OTHER CONIFEROUS LEAF MINERS

Recurvaria spp.

These leaf miners are often important pests of coniferous trees, especially pines, in the forests of the Pacific coast region. The genus is widespread throughout the United States and contains many species attacking other genera of coniferous trees besides pines. In the Yosemite National Park, Calif., great areas of lodgepole pine were killed by *Recurvaria milleri* Busck (54).

THE SATIN MOTH

Stilpnotia salicis L.

The satin moth, a recently introduced insect, has become established in the New England States. It has increased in abundance and spread with great rapidity. The caterpillars prefer poplar and willow, but will feed to a certain extent on other species of deciduous trees, chiefly oaks. The principal damage caused by the insect is the complete defoliation of many poplars and willows (13).

THE LARCH SAWFLY

Nematus erichsonii Htg.

Larch in the Northeastern States and in the Lake States is periodically defoliated by the larvae of the larch sawfly. Several of these great outbreaks occurring since 1880 have practically wiped out all the mature larch in the northeastern part of the United States and southeastern Canada.

The western larch in Idaho is similarly attacked by two related sawflies (36, 53).

THE LODGEPOLE SAWFLY

Neodiprion sp.

The lodgepole sawfly occasionally kills lodgepole pine in Idaho, Montana, and Wyoming. The most recent destructive outbreak occurred in connection with the outbreak of the lodgepole needle tier mentioned under that species.

OTHER SAWFLIES

Neodiprion spp.

Jack pine in Minnesota was severely defoliated in 1923 and 1924 by sawfly larvae of this genus. *Neodiprion banksianae* Roh. and another species near *N. scutellaris* Roh. were found attacking western yellow pine in Idaho in 1922 and young lodgepole pine in West Yellowstone, Mont., in 1924 and 1925.

During a widespread outbreak in 1926, which extended from Massachusetts to Louisiana, pines in Mecklenburg County, southern Virginia, suffered a severe defoliation, a large percentage of the pines in the county being attacked.

An outbreak of *N. excitans* Roh. severely defoliated pines in Montgomery County, eastern Texas, in 1919 and was reported as doing serious damage to pine timber.

The red-headed pine sawfly, *N. lecontei* Fitch, attacks young pines in the Eastern States and as far west as Wisconsin. Not infrequently the trees infested are completely defoliated and, as a result, are killed or severely stunted (31, 49).

THE BIRCH LEAF MINER

Phyllotoma nemorata Fallen

This sawfly was described as a new species native to America but was later found to be a known species that had been introduced from Europe. It was first discovered in North America in Nova Scotia, about 1905. Since then it has spread rapidly south and west in the birch forests of Maine, Massachusetts, and New Hampshire. The insect mines the leaves of birch, showing a preference for white birch. The defoliation is most complete late in the growing season.

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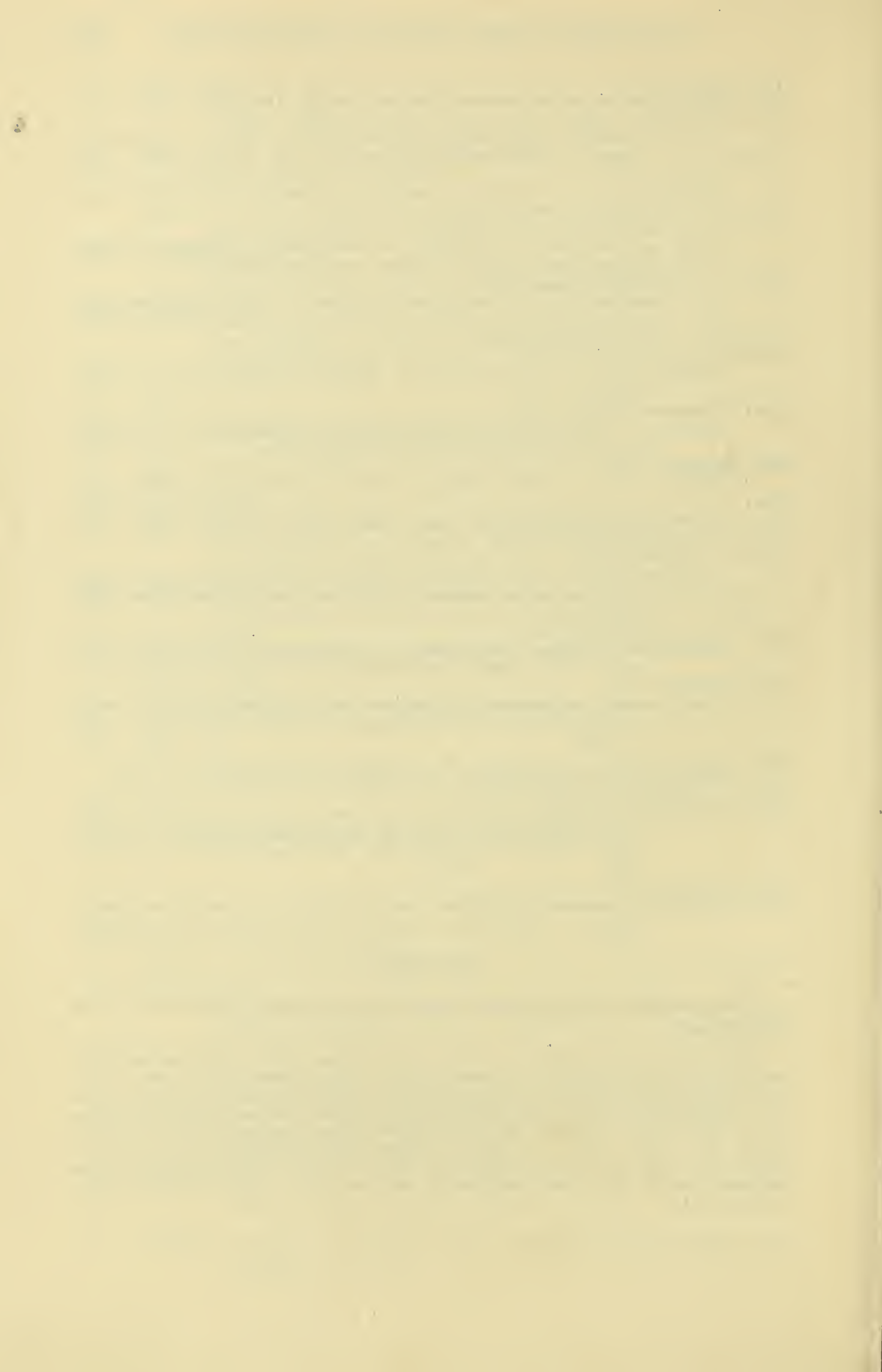
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APPENDIX

These additional references should be consulted under the species mentioned.

The southern pine beetle (85); the eastern spruce beetle (89); the engraver beetles (85); the Jeffrey pine beetle (78); the black horned pine borer (84); the belted chion (84); the cedar tree borer (84); the pole borer (86); the powder post beetle (88); the red shouldered powder post beetle (84); termites (87); the spruce twig gall lice (70, 73, 80); the pine bark louse (80); the white pine weevil (76); the European pine shoot moth (71); the pine soft scales (69); the birch leaf skeletonizer (74); the larch case bearer (82); the Pandora moth (81); the Douglas fir tussock moth (75); the birch leaf miner (83).



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